



Projected Population of the State of North  
Carolina and Its Counties  
July 1, 2021 – July 1, 2050

*Technical Document*

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Demographic and Economic Analysis Section  
NC Office of State Budget & Management  
116 West Jones Street  
Raleigh, NC 27603  
[www.osbm.nc.gov](http://www.osbm.nc.gov)

## Methods for Producing Population Projections for the State and Counties of North Carolina

### Introduction

The North Carolina State Demographer in the Office of State Budget and Management (OSBM) released on February 15, 2022, population projections for the state and counties of North Carolina, showing population by age, sex, and race/ethnicity. OSBM refers to these latest projections as the Vintage 2021 projections. We use indicator data (e.g. vital statistics, school enrollment, vehicle registration) to estimate population for past periods. Our last population estimates (Vintage 2020) were published in fall of 2021 and estimated the population for July 1, 2020. We use our population estimates to extrapolate historical population trends into the future. Our first projected population is for July 1, 2021. For this reason, these population projections are considered the Vintage 2021 population projections. We typically publish our population projections in November/December but postponed the release of these population projections in order to incorporate 2020 Census data and to review recent vital statistics to better estimate the short-term impacts of COVID-19.

The State Demographer prepared these Vintage 2021 population projections using the same general methods and assumptions to previous annual projection vintages. Mainly, the projections assume most recent trends in population change and in the components of population change (births, deaths, and net migration) continue. However, for the short term, we modified the trends to include additional deaths, fewer births, and slower net migration due to the pandemic and concomitant economic disruptions.

We rely on information from the 2000, 2010, and 2020 censuses to inform our population projection models. The US Census Bureau only published limited data from the 2020 Census in August 2021.<sup>1</sup> For this reason, we used the 2010 Census as a starting point for detailed characteristics by age, sex, and race/ethnicity while controlling for the 2020 counts of total population and population by race and Hispanic origin.

To meet the needs of our data users, we extended our projection horizon to 2050. Data users may find summaries of these projections on the OSBM website. In addition, data users may download three different datafiles. Two of the datafiles include the 2000-2020 population estimates and the 2021-2050 population projections. These two datafiles differ in the demographic characteristics presented:

1. Estimates and projections of the population for each year by sex and single years of age;
2. Estimates and projections of the population for each year and by sex, 5 categories of race (*American Indian or Alaska Native, Asian or Pacific Islander, Black, White, and Other*), and broad age groups;

The third file includes only the 2010-2020 population estimates and the 2021-2050 population projections. This file includes estimates and projections of the population for each year from 2010 through 2050 by sex, Hispanic origin (*Hispanic and non-Hispanic*) and race (*White and non-White*).

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<sup>1</sup> US Census Bureau, 2020 Census, PL94-171.

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## Limitations

Users should not compare these population projections with previous vintages because these population projections, unlike previous vintage projections, are adjusted to the 2020 Census counts. For most counties, the previous population projections were relatively close to the actual census count. At the state level the Vintage 2020 Population projections were 122,000 (or 1.2%) above the 2020 Census count. However, there were several rural counties where the 2020 Census counts came in well below what was expected in our previous estimates and projections.

Users should be aware that we made certain assumptions related to race categories. The US Census Bureau, based upon years of testing, improved their survey forms to solicit more accurate responses to questions about race and ethnicity. In addition, they improved the way responses were coded for the reported data about race. While these are welcome changes that will better reflect the diversity of our population, these changes also create challenges in bridging the race/ethnic characteristics reported in previous censuses and within the vital statistics. For the most part, we assumed that the race/ethnic characteristics reported in the 2020 Census reflect the population. Thus, we have made modifications to bridge the historical estimates to the 2020 Census information using an approximation of the US Census Bureau's Modified Age Race and Sex (MARS) data file produced in previous censuses. However, while the growth in diversity is real, we may be over- or under-stating the growth in certain populations due to the differences between the two decennial censuses.

## Methodology

### Understanding Population Change: The Demographic Balancing Equation

The demographic balancing equation has two main component processes of population change – natural change and net migration. Natural change is the difference between births and deaths within a population. Natural increase occurs when there are more births than deaths.

Net migration is the difference between the number of in-migrants and out-migrants. More in-migrants than out-migrants can provide a basis for population growth. Migrants include both migrants to and from other countries (international migration) and domestic migrants (those moving to and from other states and counties). In context of population change at the county level, any permanent move from one county to another is considered migration.

Counties experience population growth when births exceed deaths and there are more in-migrants than out-migrants. Counties can also grow when one of these main components of change (natural change or net migration) is negative as long as the positive change in the other component is large enough to exceed the negative change (e.g. +100 net migrants vs. - 50 natural change [50 births – 100 deaths] = +50 new people).

This demographic equation is useful in understanding population change, in developing methods for estimating or projecting population, or for estimating the components of

population change. Demographers use a variety of methods to project population, including those described here.<sup>2</sup>

### Projection Model

The current population projection model includes two main components: a forecast model to project total population and population of each major race and Hispanic origin group, and a cohort-component method to model the projected change in the age characteristics of the population.

First, the total household population was projected for each of the 100 counties in North Carolina using time-series forecasting models that pattern future population change based upon historical trends in population for each county. For the current set of projections, OSBM selected a forecast model for each county that most accurately projected the 2010 through 2020 estimates. We selected projections that had low predicted errors [measured in terms of Mean Absolute Percentage Error (MAPE)]. OSBM then added the group quarters population to the projected household population for each county to obtain the projected total population for each county for each year from 2021 through 2050. The summation of these projected total populations for each county yielded the total population by year for the state of North Carolina.

After preparing projections of the total population for all counties and the state, OSBM prepared the population of each sex and race group and each sex and Hispanic origin group combination using time-series forecast models. We then controlled the resulting projections by sex, race, and Hispanic origin to the projections of the total population for each county. The office then summed these sex, race, and Hispanic origin population projections for each county and year to obtain the sex, race, and Hispanic origin population projections for the state.

### Cohort-Component

#### *Race/Sex/Age characteristics*

OSBM used a cohort-component technique to project the age characteristics of each sex and race combination. Estimated survival rates for each age, sex and race combination are based on data from the 2000 and 2010 censuses.<sup>3</sup> We adjusted these survival rates based upon actual reported deaths by age, sex, and race between 2010 and 2020 and further adjusted for

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<sup>2</sup> Steve H. Murdock and David R. Ellis, *Applied Demography: An Introduction to Basic Concepts, Methods, and Data* (Boulder, CO: Westview Press, 1992); Steve H. Murdock et al., *Demographics: A Guide to Methods and Data Sources for Media, Business, and Government* (Boulder, CO: Paradigm Publishers, 2006); Jacob S. Siegel, *Applied Demography: Applications to Business, Government, Law, and Public Policy* (United States of America: Academic Press, 2002); Stanley K. Smith, Jeff Tayman, and David A. Swanson, *State and Local Population Projections : Methodology and Analysis, The Plenum Series on Demographic Methods and Population Analysis* (New York: Kluwer Academic/Plenum Publishers, 2002); Bryan, Thomas. 2004. "Population Estimates." Pp. 523–60 in *The Methods and Materials of Demography*, edited by J. S. Siegel and D. A. Swanson. Amsterdam: Elsevier.

<sup>3</sup> Detailed age characteristics from the 2020 Census were not yet available.

2021 and 2022 to account for the impacts of the pandemic. We assumed survival rates would remain the same from 2022 through 2050. OSBM applied these survival rates to the population for each group at the beginning of each period to project the survived population for the subsequent year (the population assuming no net migration). We derived estimated net migration by subtracting the survived population for the following year from the population as projected by the time-series forecasting models (described above). OSBM adjusted this total net migration for each county for each year for age specific rates of net migration by using net migration trends by age from 2000-2010. The resulting net migration by age for each sex and race group added to the survived population by age, sex and race yielded the final projected population by age; the process was repeated for the next period.

We prepared an initial model with the derived measures of total net migration based upon forecasted trends. Then, we reduced net migration for 2020 and 2021 to account for restrictions on international migration and the impacts of the economic downturn on domestic migration. Beginning in 2022, the model assumes the level of net migration returns to the previously projected trends. The final step was to add the population at the youngest age by applying the most recent race specific birth rates by race for the female population age 10 to 49. Pre-pandemic fertility rates (average over 2017-2019) were used for 2022 through 2050. Reported births for 2020 and 2021 were utilized for 2020 and 2021.

## Data

### Historic Population

The most fundamental part of any population projection are the historical data from which the projections are derived. The Vintage 2020 certified and revised county population estimates produced by OSBM and released in September 2021 were used to project future populations.<sup>4</sup> The decennial censuses serve as a basis for the population estimates and projections this office produces, especially the 2000 and 2010 decennial censuses. Although detailed data from the 2020 Census were not yet available, population totals by race for each county were used to benchmark the July 1, 2020, population estimate and revise the 2010 through 2019 population estimates.

OSBM obtained 2000 and 2010 decennial census population by race, sex, and single years of age from 0-99 and a combined age group for population age 100+ from the US Census Bureau's 2000 and 2010 Modified Age, Race, and Sex (MARS) file. The race categories used in these projections include: *American Indian or Alaska Native, Asian or Pacific Islander, Black, White, and Other*. We report Hispanic origin (*Hispanic or non-Hispanic*) separately in these projections and we further categorize Hispanic origin by race: *White or non-White*.

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<sup>4</sup> *Certified Estimates of the Total Population of North Carolina Counties for July 1, 2020, and Revised Estimates of the Total Population and Population by Age, Sex, Race, and Hispanic Origin of North Carolina Counties for 2010 through 2019.*

The MARS file has not been produced for 2020. To produce population projections this year, OSBM prepared an approximate MARS file by using the same logic as that used for the 2010 MARS file. The logic is as follows:

1. All persons reporting a single identified race are coded as that race (e.g. *Black Alone = Black*);
2. All persons reporting three or more races are coded as *Other*;
3. All persons reporting two identified races are coded as *Other* (e.g. *White & Black = Other*);
4. All persons reporting as an identified race & *Some Other Race (SOR)* are re-coded as the identified race (e.g. *Asian & SOR = Asian or Pacific Islander*);
5. Finally, the *SOR Alone* category was apportioned to a race category based upon allocations used in the 2010 MARS data. The allocations were as follows: (*American Indian or Alaska Native: 6%; Asian or Pacific Islander: 2%; Black: 8%; and White: 82%, Other: 2%*).<sup>5</sup>

We prepared an initial set of estimates and projections using the 2010 Census MARS data and then controlled to the 2020 Census modified values as described above.

The base population estimates incorporated corrections to the 2010 Census count as a result of the Count Question Resolution (CQR) program. The CQR correction included a major change in the group quarters population for Durham and Granville County (the population of several prison facilities were incorrectly counted in Granville County rather than Durham County in 2010).

### Vital Statistics

The North Carolina State Center for Health Statistics provided vital statistics data for the years 2000 through 2020, which include recorded births and deaths by county of residence. OSBM used the data to calculate mortality and fertility rates and derive estimates of net migration for counties for the 2000 to 2010 period. In addition, OSBM reviewed preliminary vital statistics by month in 2021 to modify mortality and fertility rates to account for COVID-19 for 2020 and 2021. Because the birth data rely on the race/ethnicity of the mother to assign race/ethnic characteristics of the child, multi-racial births are likely under-reported. For this reason, we adjusted the race characteristics of children at birth to age 1 (age 0) based upon estimates from the American Community Survey.

### Group Quarters

Every year, OSBM obtains group quarters population counts for hundreds of facilities within the state from various federal and state agencies, as well as through an annual survey of municipalities and counties. These group quarters include college and university dormitories,

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<sup>5</sup> Persons of Hispanic ethnicity can be of any race.

state and federal prisons, military quarters, and nursing homes, among other facilities. Because demographic change for group quarters population do not follow the same pattern as the general population, it is necessary to account for this population by excluding it from the general projection model and then adding it back to obtain the final projections of the total population. For the purposes of producing population projections, with one exception, OSBM assumed that the group quarters population for each county for all future years remained the same as it was in 2020.<sup>6</sup> A private prison in Hertford County closed in May 2021. Thus, the projections for Hertford County were adjusted to account for the loss of that prison population.

## Assumptions

Both population estimates and population projections rely on historical data that are symptomatic of population change to approximate historical or future populations. For these population projections, we assumed that pre-pandemic patterns of change in total population and rates of fertility and mortality continue through 2050, except for 2020 and 2021 – the years most impacted by the pandemic. We assume that the pandemic will be under control some time in 2022, with full recovery to pre-pandemic conditions by 2023.

### Total Population Change

As described above, the forecast model uses historical data to project total population and total population by sex, race, and Hispanic origin through 2050. With the exceptions of the adjustments made to account for the impacts of COVID-19 in the short term, these projections assume that pre-pandemic trends in population change will continue.

### Fertility

Prior to the pandemic, the precipitous decline in fertility rates that began during the Great Recession halted and fertility rates have remained stable, but at a rate much lower than in the 1990s and early 2000s. At the peak in 2007, there were 69.6 births to women aged 15 to 44. This rate dropped to 58.4 by 2018.<sup>7</sup> These population projections assume fertility rates remain constant through the projection period, and use a three-year (2017, 2018, and 2019) average of age- and race-specific fertility rates. The projections also assume a constant distribution of births into male and female for each race group through the projection period equal to the average of the corresponding fractions for calendar years 2010 through 2020.

North Carolina began to experience the impacts of the pandemic in March 2020. The effects on fertility began to show by the end of 2020. Statistics on births showed a decline in the

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<sup>6</sup>This is based partly on information provided by major sources of groups quarters populations, including prisons (North Carolina Sentencing and Policy Advisory Commission), military installations, and college and universities.

<sup>7</sup>Joyce Martin et al., “Births: Final Data for 2007,” National Vital Statistics Reports (Hyattsville, MD: National Center for Health Statistics, 2010); Joyce Martin et al., “Births: Final Data for 2018,” National Vital Statistics Reports (Hyattsville, MD: National Center for Health Statistics, 2019).

number of births in the final months of 2020 when compared to previous years. Other states and countries showed similar trends. In 2020, births were about 3% below that of 2019. Preliminary birth statistics for 2021 indicate that births remain lower than pre-pandemic levels but not as much as we predicted last year. For these projections, we adjusted the 2021 births to match a short-term forecast of births based upon preliminary birth data by month for 2021. We used the pre-pandemic fertility rates for 2022 and beyond.

### Mortality

Following the 2010 Census, OSBM prepared an unabridged lifetable<sup>8</sup> for 2010. Except for 2020 through 2022, survival rates obtained from this lifetable were assumed to remain constant through the projection period with adjustments to the survival rates based upon actual deaths that occurred through 2020. In January 2022, the 20,000<sup>th</sup> COVID death was recorded. Although 2021 death statistics are incomplete, a review of the preliminary data show trends consistent with those seen in other states and countries – that deaths from all causes will once again be more for 2021 than what we would have expected given the state’s population age structure. At the national level, preliminary estimates have shown a one-year reduction in life expectancy at birth as a result of COVID-19.<sup>9</sup> A review of preliminary, though incomplete, death statistics by month for 2021 provided some guidance on likely trends for the short term. Thus, these projections assume higher mortality rates for 2021 and 2022, with rates returning to pre-pandemic levels of age, sex, and race mortality some time in 2023.

### Net Migration

As previously outlined, the forecast model uses historical data to project total population and total population by sex and race through 2050. Net migration was then derived from a residual between the forecast model and the cohort-component model. The resulting derived measure of total net migration provided a reasonable assumption about future levels of net migration based upon recent trends. Net migration is difficult to predict when not challenged by the effects of a global pandemic, but international migration was restricted in 2020 and the economic downturn and other factors led to reduction in domestic migration as indicated by surveys and other symptomatic indicators.<sup>10</sup> For these reasons, net migration was lower in 2020 compared to pre-pandemic periods and we adjusted migration downward for 2021 based upon a review of a variety of indicators. This adjustment was based upon the

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<sup>8</sup> An unabridged life table shows the probabilities of someone dying for each age. These probabilities are converted to survival rates to estimate the population living in the following year.

<sup>9</sup> Elizabeth Arias, Betzaida Tejada-Vera, and Farida Ahmad, “Provisional Life Expectancy Estimates for January through June, 2020,” National Vital Rapid Release (Hyattsville, MD: National Center for Health Statistics, February 2021).

<sup>10</sup> Cynthia Paez Bowman, “Coronavirus Moving Study: People Left Big Cities, Temporary Moves Spiked In First 6 Months of COVID-19 Pandemic,” January 20, 2021, <https://www.mymove.com/moving/covid-19/coronavirus-moving-trends/>.



assumption COVID-19 reduced international migration to near zero in 2020 and domestic migration would continue at a reduced rate. The Census Bureau estimates that about a quarter of North Carolina's net migration from 2010 and 2019 was attributed to international migration.<sup>11</sup> Beginning in 2022, the model assumes the level of net migration returns to the previously projected trends.

## Adjustments

### Institutional Effects

When a large institution – such as a college or prison – is located within a county, its population characteristics can lead to errors in the county's projected population characteristics if the institutional population is not properly accounted for. Many counties may have a relatively large younger population solely because one of these institutions is present. College students are likely to move elsewhere once they graduate from their university. For this reason, OSBM modified the population projections to account for change in certain institutions, such as colleges, universities, military installations, and, to a lesser extent, prisons and some state hospitals. There are twelve counties in North Carolina with age structures significantly affected by institutions. These counties and the major institution types that affects them are: Avery (prisons and college), Craven (military), Cumberland (military), Durham (university), Jackson (university), Madison (university), New Hanover (university), Onslow (military), Orange (university), Pasquotank (university and prisons), Pitt (university), and Watauga (university). OSBM adjusted the projections to account for institutional populations and assumed that the institutional population would stay constant at 2020 levels.

### Projection Controls

OSBM controlled the initial set of population projections for total population from 2010 through 2020 to the independently derived estimates of the total population for counties. The projections were controlled to the revised estimates for 2010 through 2019 and for the certified estimates for 2020.

Then, we controlled the estimates and projections of the population by race, sex, and Hispanic origin of each county to the estimates and projections of the total population of each county for the estimation/projection period (2010 through 2050).

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<sup>11</sup> US Census Bureau, Vintage 2020 Population Estimates for States